DISCUSSION

Conventional indices of tissue perfusion after surgery involving cardiopulmonary bypass (CPB) may not accurately reflect disordered cell metabolism. Venous hypercarbia leading to an increased veno-arterial difference in CO_2 tension ($_V$-a CO_2 gradient) has been shown to reflect critical reduction in systemic and pulmonary blood flow that occur during cardio-respiratory arrest and septic shock.

A prospective study was conducted on 70 patients of both sex who underwent cardiac surgery under cardiopulmonary bypass. These patients were followed up for a period of 28 days for the development of complications and mortality.

In addition to the conventional parameters of evaluating the patients haemodynamics, also veno-arterial carbon dioxide gradient and lactate level have been recorded and categorized at three stages T3, T6 and T12.

The aim of this study was to evaluate the role of veno-arterial carbon dioxide difference and lactate level in the prediction of the development of complications in patients undergoing cardiac surgery under cardiopulmonary bypass.

The mean age in the current study was 49.2 years, as it is the age by which the symptoms of ischemic heart diseases is likely to occur, and also symptoms of valve affection increase.

This was similar to other studies such as Ziauddin A et al [(98)] in which the mean age was 47.1 years.

This study the majority of patients were males 62.9 % and only 37.1 % were females.

This was similar to Ziauddin A et al [(98)]. In their study males were 66 % and 34 % were females.

The gender in both studies had no significant effect on the incidence of complications.

Arrythmias were the most common complication that occurred in the present study. Its incidence was about 23 % of all patients included in this study. The incidence is greater in patients undergoing valve replacement as it was 37% than those undergoing CABG as it was 15.7%.

In agreement with the present study, Giovanni Pertto et al [(99)] reported that the incidence of arrythmias in patients in the early postoperative period after CABG was up to 40 % and 37-50 % after valve surgery.

Poor inotropy or poor cardiac output syndrome after cardiac surgery is not uncommon, its frequency in our study was 10 %.

In agreement with Vivek R et al [(100)] study, in which 4558 patients who underwent cardiac surgery at the Toronto hospital between July 1,1990 and December 31,1993. were involved. The overall prevalence of low cardiac output syndrome was 9.1 %.

Acute renal failure after cardiopulmonary bypass surgery in the present study was 8.2 %. This finding was supported by Khilji et al [(101)]. In the present study 500 patients underwent cardiac surgery on cardiopulmonary bypass 7.7 % of them developed acute renal failure.

Delirium is a common complication after cardiac surgery. In the present study the incidence of delirium was 11.4 % in agreement with Ieva N et al [(102)] study where 87 patients underwent cardiac surgery at Vilnius university hospital, were prospectively monitored for post operative delirium development during intensive care unit stay, the incidence of post operative delirium was 13.3 %.

Meanwhile unlike our study the incidence of delirium after cardiac surgery on bypass was 46 % in Jenifer G [(103)] study. This can be explained by the age of the studied group in this study in which they studied 225 patients aged from 60 to 90 years who underwent coronary artery bypass grafting or heart valve replacement surgery.

In this study the incidence of stroke developed only in one patient representing 1.4 %. This was supported by Charles W et al [(104)] study in which stroke occurred in 1.5 % of the studied cases.

Cardiac arrest during intensive care unit stay is a rare complication. In the present study it didn't occur in any patient, while its incidence in other studies such as Thomas Pezzella[(105)] was 1.4 % and this can be explained by the large sample in their study in which more than 160000 patients were involved

The mortality rate in the present study was 4.3 %, this finding was supported by the auditing of the national adult cardiac surgery audit report, in their annual report the mortality after cardiac surgery on bypass was ranging between 3.1 % and 4 % from 2010 to 2011. [(106)]

In the present study lactate level was significantly higher in patients with high carbon dioxide difference (above 6 mmHg) at different times postoperatively as in patients was $\Delta PCO_2 > 6$ mmHg at T3, lactate level was 2.96 ± 0.91 mmol/L but in the group of $\Delta PCO_2 \leq 6$ mmHg, lactate was 2.06 ± 0.6 mmol/L ($P < 0.001$).

Also at T6 in the group with $\Delta PCO_2 > 6$ mmHg lactate level was 2.63 ± 0.85 mmol/L, but in patients with $\Delta PCO_2 \leq 6$ mmHg it was 1.28 ± 0.34 ($p < 0.001$).

At T12 high ΔPCO_2 group had lactate level 2.12 ± 0.46 mmol/L but low ΔPCO_2 group had lactate level of 1.16 ± 0.25 mmol/L.

In agreement with the present study, Vallée F et al [(95)] studied 50 consecutive septic shock patients with $S_{cv}O_2 > 70$ % and measured the central venous to arterial carbon dioxide difference and lactate at T6 and T12. Patients were separated in low ΔPCO_2 group (n = 26) and high ΔPCO_2 group (n = 24) according to threshold of 6 mmHg. The study reported that lactate level was significantly lower in patients with lower ΔPCO_2.

In the present study high ΔPCO_2 was related to post operative complications as at T3 among 41 patients with $\Delta PCO_2 > 6$ mmHg 20 patients contributing 48.8 % developed complications, although in 29 patients with low ΔPCO_2 only 6 patients contributing 20.7 % developed one or more complications ($p = 0.017$), and t T6 70.4 % of patients with high

ΔPCO_2 had one or more complications, in the same time only 16.3 % of the patients with low ΔPCO_2 had one or more complications ($p < 0.001$).

This finding was supported by Jan B et al [107] who studied ΔPCO_2 in 64 patients with septic shock and concluded that ΔPCO_2 is related principally to cardiac output, also to the degree of pulmonary impairment also $\Delta PCO_2$was larger in non survivors.

In the present study patients who had normalized ΔPCO_2 at T6 after admission to ICU, had a greater lactate decrease with lower lactate concentrations. It means that the decrease in lactate level over the first six hours was higher in the subgroup achieving a normal ΔPCO_2.

This finding matches with the results of recent study of Jihad M et al [108]. In their study eighty patients with septic shock were included. Blood lactate concentration and hemodynamic and oxygen derived variables were obtained at the intensive care unit admission and 6 hours after admission. They concluded that the normalization of central venous to arterial carbon dioxide difference is associated with greater decrease in lactate concentration.

The present data demonstrate a strong relationship between high ΔPCO_2 and development of complications after cardiac surgery. At T6 83% of patients with ΔPCO_2 developed no complications, while 70 % of patients with high ΔPCO_2 developed at least one complication, also at T12 84 % of patients with normal ΔPCO_2 were without complications, but 76 % of patients with high ΔPCO_2 developed one or more complication, this finding was supported by Jihad M et al [108].

In the present study there was progressive falling in the veno-arterial CO_2 difference by time as ΔPCO_2 at T3 was 7.13 ± 2.04 mmHg, while at T6 ΔPCO_2 was 5.71 ± 2.7 mmHg and at T12 it was 5.59 ± 2.62 mmHg.

The falling in veno-arterial CO_2 difference was associated with progressive decrease in lactate concentration as lactate level at T3 was 2.58 ± 0.91mmol/L, at T6 it was 1.80 ± 0.88 mmol/L and at T12 lactate level was 1.50 ± 0.57 mmol/L. This finding was supported by the study of Ariza M et al [109]. In their study an open prospective trial was carried out in ten adult patients (8 males, mean age 56.1, range 30-73 years) scheduled for surgery involving cardiopulmonary bypass. They reported that veno-arterial CO_2 gradient fell progressively with time.

In the present study a cutoff value of ΔPCO_2 was obtained by which the complications start to develop after the analysis of ROC curve. This cutoff value at T3 was 8 mmHg with sensitivity of 46.15 % and specificity of 90 %. The cutoff value of ΔPCO_2 at T6 and T12 was 6 mmHg with specificity of 81.8 % and 86.3 % respectively and sensitivity of 73.08 % in both.

This finding was supported by Martin D et al [110] where the cutoff value of ΔPCO_2 was 6 mmHg.

SUMMARY

Most cardiac surgery is currently being performed under cardiopulmonary bypass, it introduces a unique set of potential postoperative complications, that may result in low flow in the microcirculation of the heart, brain, and other organs, which may lead to organ dysfunction, so identification of predictors of morbidity and mortality is an important issue.

Central venous to arterial carbon dioxide partial pressure difference (ΔPCO_2) can be used as a marker for the efficacy of venous blood in removing the total CO_2 produced by the tissues. To date, this role of ΔPCO_2 has been assessed only in patients after resuscitation from septic shock. There is no report on the behavior of ΔPCO_2 and its relationship to clinical outcome after cardiac surgery.

The aim of this work was to assess the prognostic value of ΔPCO_2 in post cardiac surgery patients.

This study included 70 patients underwent elective cardiac surgery under CPB. All patients were in the age group between 18-60 years. Arterial and central venous samples were obtained simultaneously at T3, T6 and T12 after admission to ICU, and PCO_2 and lactate level were recorded. All patients were followed up for postoperative complications and 28-days mortality.

The results of this study showed that:

- Mean ΔPCO_2 at T3 was 7.13 mmHg, while it was 5.7 mmHg at T6 and 5.59 mmHg at T12.
- Patients with $\Delta PCO_2 \leq 6$ mmHg at T3 represent 41.4 % of the studied cases, while at T6 they represent 61.4 % and at T12 they represent 64.3 %.
- Mean lactate level was 2.58 mmol/L at T3, 1.8 mmol/L at T6 and 1.5 mmol/L at T12.
- Lactate level was significantly higher in patients with $\Delta PCO_2 > 6$ mmHg than those with $\Delta PCO_2 \leq 6$ mmHg at T3, T6 and T12.
- There was statistically significant decrease in serum lactate level with normalization of ΔPCO_2 from T3 to T6 and from T3 to T12.
- The incidence of complications was significantly higher in patients with $\Delta PCO_2 > 6$ mmHg than in those patients with $\Delta PCO_2 \leq 6$ mmHg at T3, T6 and T12.
- Arrhythmia was the most common complication among studied cases with incidence of 22.9 % followed by delayed recovery 17.1 %, delirium 11.4 %, poor inotropy 10 % and acute renal failure 8.6 %.
- 28-days mortality represented 4.3 % of the studied cases.
- ΔPCO_2 Cutoff value of 6 mmHg can predict postoperative complications with high specificity and sensitivity at T6 and T12.

CONCLUSION

From this study it was concluded that:

Central venous to arterial carbon dioxide partial pressure gradient may be considered as a good prognostic parameters in post cardiac surgery patients.

Patients with central venous to arterial carbon dioxide gradient more than 6 mmHg at T6 and T12 may be at high risk of developing postoperative complications.